CWIP

Initial Environmental Review of NWC Treatment Facilities in Negril

ARD

Coastal Water Quality Improvement Project

USAID Contract No. 532-C-00-98-00777-00

Initial Environmental Review of NWC Sewage Treatment Facilities in Negril

January 2001

Prepared for the:

Government of Jamaica's
National Environment and Planning Agency

And the

United States Agency for International Development

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Abbreviations

ASP	Activated Sludge Process
BOD	Biochemical Oxygen Demand
d	Day
CWIP	Coastal Water Quality Improvement Project
COD	Chemical Oxygen Demand
COD-f	COD of the filtered sample
COD-m	COD of the completely mixed sample
h	Hour
EMS	Environmental Management Systems
FTU	Formazine Turbidity Units
HRT	Hydraulic Residence Time
GOJ	Government of Jamaica
InWaSia	In Waste water Systems interactive (iterative) approach
ISO	International Organisation for Standardisation
Kg	Kilogram
L	Litre
m^3	Cubic Meter
mS	Milli Siemens
mV	Milli Volt
N	Nitrogen
NH_3-N	Ammonia Nitrogen
NO_3-N	Nitrate Nitrogen
NEPA/NRCA	National Environment and Planning Agency/Natural Resources Conservation Authority
NWC	National Water Commission
o-P	Ortho-Phosphate
P	Phosphorous
PE	Population Equivalent
PS	Pump Sump/Sewage Relift Station
T	Tons (Metric)
SRT	Solids Retention Time
STP	Sewage Treatment Plant
SVI	Sludge Volume Index
UASB	Upflow Anaerobic Sludge Blanket Reactor
WC	Water Column

Background to the Project

In recent times concern about the impact of non-point (diffused) sources of sewage on the coastal resources of Negril had become a matter of concern. Responding to the concerns of the local community, the government of Jamaica constructed a central wastewater system in Negril to serve the Norman Manley Boulevard as far north as the new Breezes hotel, the West End area as far as the lighthouse, the residential areas of White Hall and Red Ground, also Non Pariel Road. Construction, which began in September 1994, was facilitated with funding from the European Union. The system was commissioned in 1998 and to date has been treating approximately half of its design capacity.

The treatment system employs the facultative process in a series of ponds to treat the waste stream generated within the collection area. The ponds are arranged in two parallel rows, with each row having two facultative units and a maturation unit arranged in series. The ponds are built in peat within the Negril wetlands, and receive groundwater flow during most of the year. The water table in this area fluctuates throughout the year. Only one set of ponds is being used at this time because of the present inflows. As inflows increase, the second set will be brought on stream.

Since commissioning, the structural integrity of the embankments surrounding the ponds appear to have been compromised because of the soil type supporting the system, resulting in a sinking of the embankments and causing an assumption that the general depth within the ponds has been reduced. These concerns, coupled with the presence of a static level of ground water within the ponds, could compromise the treatment process, eventually leading to the production and discharge of improperly treated effluent to the South Negril River.

Concerns have also been raised about the ponds ability to remove nutrients. An increased nutrient load into the South Negril River eventually reaches the coastline and could exacerbate the current situation regarding reef health. In this regard there has been an ongoing discussion about the potential benefits of tertiary treatment as on option for nutrient removal.
In light of these concerns of the performance of the Negril Treatment Plant and its ability to remove nutrients the Coastal Water Improvement Project (CWIP) to Contract Result 2 (CR 2) commissioned an assessment of the ponds capacity and capability to meet its design criteria. The National Water Commission (NWC) fully supported the project as the results were seen to be useful to its existing operations.

Background on the Consultants

CWIP contracted two short-term experts to provide the technical assistance to conduct the initial environmental review and to provide an overview of the performance of the Negril Systems. A brief introduction to the two consultants is found below.

- Robert Wynter is a Chemical Engineer and Management Consultant with wide experience in environmental audits and EMS'.
- Johan Verink is an Environmental Engineer with commitment to the development, adaptation, transfer and implementation of know-how in the wastewater treatment sector.

This document outlines the findings of the technical assessment which was undertaken in conjunction with an initial environment review (IER) of the Negril waste water system[1]. The IER included continuous on-line monitoring and sampling of the pond and an assessment of pond performance. The data from that exercise has been incorporated in our considerations of pond performance along with a review against design criteria and NEPA/NRCA standards.

[1] Initial Environmental Review of NWC Sewage Treatment Facilities in Negril, Ocho Rios and Montego Bay - Negril Report, December 2000

Purpose of the Study

The purposes of this study are to:

1. Provide a performance review of the facilities.

2. Determine whether or not the Negril plant as presently configured will perform as per design criteria, and whether the treated effluent will be in compliance with regulatory standards.

Tasks

The proposed tasks for the consultant are as follows:

1. Review documents related to design, construction, and operations of the systems to be reviewed;

2. Review and analyse NWC records describing concentrations of water quality parameters found in the final effluent at the Negril plant since it commenced operation.

3. Use the data from IER to inform the assessment of the ponds

4. Liaise with NWC's operational staff at the Negril facilities re the provision of existing information to be incorporated into the report.

5. Prepare the Negril plant capacity and capability assessment report.

Organisation of the Report

This report reviews the design of pumping stations and treatment ponds, followed by an assessment of the performance of the system based on the design criteria. Finally recommendations are made to improve plant performance to meet NRCA effluent standards.

Overview of the Negril Sewage Treatment Plant

Location

Eleven (11) pumping stations are located along the coastline in Negril. Fig. 2 shows a typical cross-section of a pumping station. Fig. 3 shows the design details. The wastewater treatment ponds (Fig. 4) are located adjacent to the Negril Golf Club. It shows an overview of the sewage collection and treatment system.

Type

Two parallel operated series of three ponds.

Disposal

Screenings are removed daily and disposed off. Sludge is deposited in the ponds. Effluent is discharged into the South Negril River and eventually to Negril Bay.

Photographic Display (See pictorial appendix):

- Get going
- Sump / Pumping Station 3
- Venturi Canal with Screen
- Ponds and pond investigations
- Pilot Plants

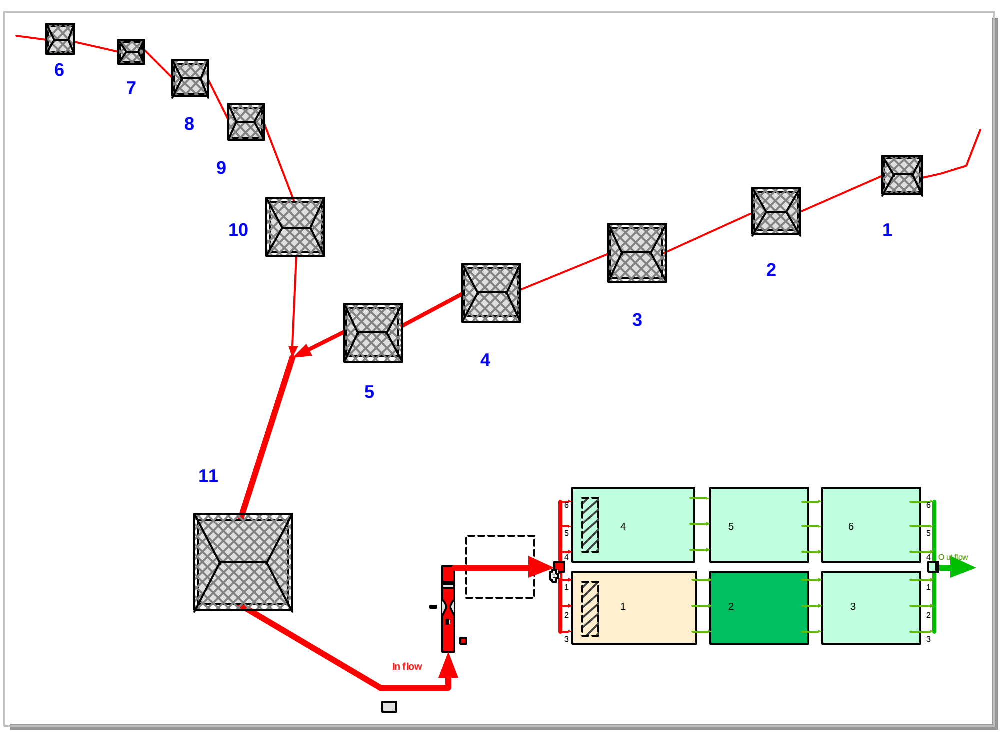


Fig. 1 Schematic of Negril Sewage Collection and Pond Treatment System

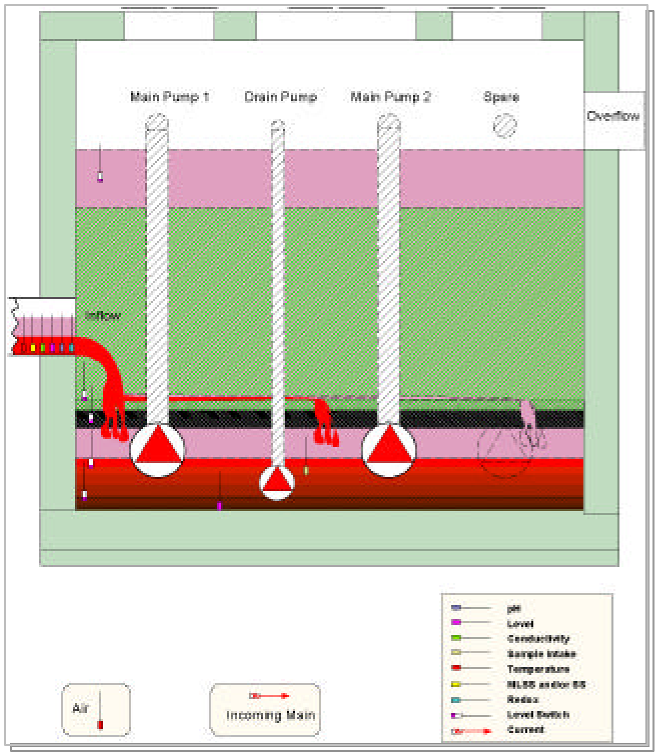


Fig. 2 **Cross-Section of Pump Sump 3**

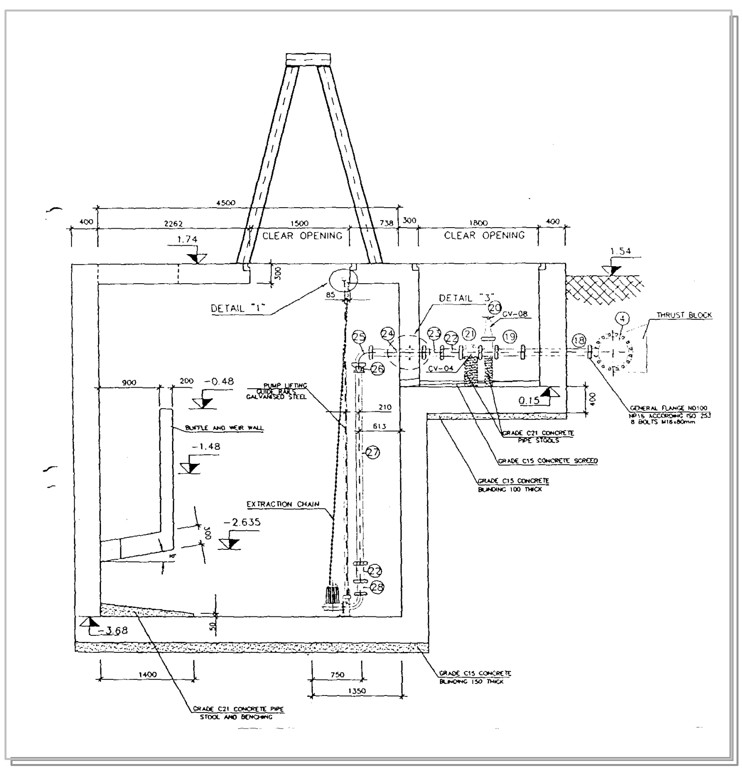


Fig. 3 **Design of Pump Sump 3**

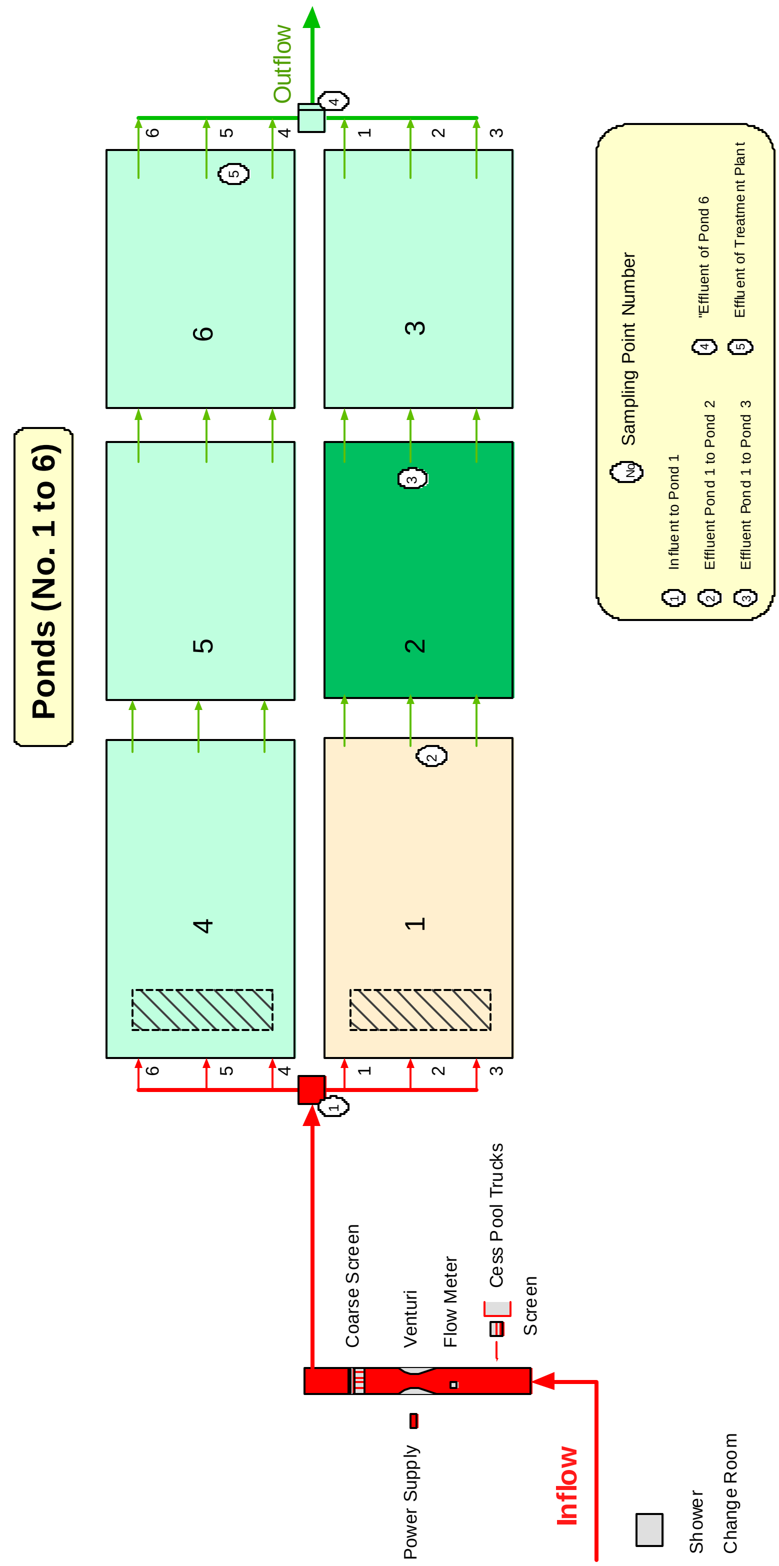


Fig. 4 **Schematic Overview of Negril Waste Water Treatment Ponds**

Findings

In approaching this task, the consultants reviewed an number of documents; held discussions with NWC technical team; Reviewed Publications[2]; and took on-site measurements. In the first instance the on-site measurements took place n November, however later in January the ponds were observed on three separate occasions to verify observations and to cross-check measurements.

The following section presents the findings, firstly with an evaluation of the design criteria, secondly the presentation of general observations and finally the presentation of options for improvements along with next steps to improving plant performance.

Design Review

A summary of the design criteria and actual findings with comments are shown in the three tables below.

The actual design details are found in the appendix.

[2] Sewage Treatment in Hot climates. Duncan Mara (1976), Experiences with Pond Treatment (AIT, Bangkok, 1989 – 1993).

	Unit	Design	Actual	Actual (%)	Remarks
Number of Ponds in Use	n	6	3	50	Only series of three ponds being used. Reason: Not all of population connected to the system
	m3/d	15898	4600	29	As above and maximum for a population in 2015 in winter
BOD - Influent	mg/L	177	118	67	Indication that infiltration water or excessive water consumption exists
	mg/L		293		Not included in the design
pH in Influent	-		7.1 - 7.4		Not included in the design
	mS/cm		1.3 - 1.9		Not included in the design
Faecal Coli - Influent	MPN/100 mL	24000000	up to 81000000		Significantly higher than in design
	C	25	26	104	Temperature is above minimum

Tab. 1. Design Parameters, Actual and Comments I

	Unit	Design	Actual	Actual (%)	Remarks
Pond Sizes	Unit	Design	As Built	Actual (%)	Remarks
Free board	m	0.5	0.1 - 1.0		Less and more than designed
Width of Sludge Collection	m	10	0	0	Sludge colletion sump is full
Depth first pond	m	1.75	1.6	91	
Depth second pond	m	1.5	1.1	73	Later decided to provide same width as pond 1
Depth third pond	m	1.5	1.5	100	Pond number 5 is partly very shallow
Width first series of ponds	m	100	110	110	
Width of second series of ponds	m	70	110	157	
Length of first pond	m	300	300	100	
Length of second pond	m	225	225	100	Later decided to provide same width as pond 1
Length of third pond	m	225	225	100	Later decided to provide same width as pond 1
Area first two ponds in series	ha	6.0	3.3	55	
Area first two second ponds in series	ha	3.2	2.5	79	
Area third two third ponds in series	ha	3.2	2.5	79	
Total Area of one series of ponds		12.3	16.5	134	
HRT - Pond 1	d	6.6	11.5	174	Actual HRT more than design / not a problem
HRT - Pond 2	d	3.0	5.9	199	Actual HRT more than design / not a problem
HRT - Pond 3	d	3.0	8.1	272	Actual HRT more than design / not a problem
Total Actual HRT	d	12.5	25.5	203	
Total Actual Area Used	ha		8.3		Short Circuiting Observed

Tab. 2. Design Parameters, Actual and Comments II

	Unit	Design	Actual	Actual (%)	Remarks
BOD - Load used ponds	kg/(ha.d)	229	66	29	
	kg/(ha.d)		163		Not inluded in the design
N-Load - receiving water more than	kg/(ha pond.a)		1689		Not inluded in the design
	kg/(ha pond .a)		468		Not inluded in the design
Effluent Quality	Unit	Design	Actual	Actual (%)	Remarks
	mg/L	53	30 - 187		
BOD - Effluent pond 2	mg/L		9 - 128		
	mg/L	11	9 - 128		BOD determination requires attention (verification/justification)
COD - Final Effluent	mg/L		95 - 110		Not included in the design
	MPN	1970	1100 - >> 2400		Inadequate treatment
N geater than	mg/L		8.3		Inadequate treatment
	mg/L		2.3		Inadequate treatment
pH	-		7.1 - 8.6		Depending on algal activity
	mS/cm		1.5		Higher than usual for domestic waste water

Design Parameters, Actual and Comments III

Number of Ponds in Operation and Flow Rate

Only one series of ponds is in operation, because the ponds were designed to meet the projected population in 2015. Currently the flow rate is only 29 % of design and hence the decision to use only one series of ponds.

BOD Influent

The actual BOD is 33 % lower than the designed BOD and indeed lower than expected for typical sewage influents in Jamaica (Tab. 1.). The salt content (conductivity) at the pumping station # 3 indicates that there is infiltration water into the sewer which results lower BOD levels.

Faecal Coliforms Influent

The design was based on 2,4 10^7 MPN/100 mL (Tab. 1.), however the NWC values revealed some values were up to 8,1 10^7, which is three times higher than in the design.

Pond Sizes

Freeboard, which is designed for 0,5 m, varies between 0,1 and appr. 1,0 which is due to settling of the dikes into the peat (Tab. 2.).

Sludge Collection Basin

The design width of the sludge collection basin in pond 1 is 10 m. It is now completely filled which shows that the design width is too small.

Facultative Pond in Use

Design length and width of facultative ponds are 300 and 100 m and was built to design specifications, however the depth of the ponds is 1,6 m as opposed to the design depth of 1,75 m. Observations at the levels of the dikes indicate they have sunk, however it could be also the complete system that has sunk, resulting in a lower than designed depth. This has resulted in a 9 % short fall in the volume (Tab. 2.).

Maturation Ponds in Use

The length of the maturation ponds is 225 m as designed, however the width were at a 100 m (Tab. 2.). It is our understanding that the width was later changed to 100 m, but not documented. The depth of the first maturation pond is 1,1 m versus a design of 1,5 m. This has resulted in a 27 % reduction in the depth of the pond. The second maturation pond has a depth of 1,5 m as designed. The fact that this pond has not is not below the design depth suggests that the entire pond has sunk, the dike has sunk or that the original pond was built deeper.

The second series of ponds (P4, P 5 and P 6) were very similar to the series currently being used (P1, P2 and P3).

In two areas of the maturation ponds accumulation of anaerobic sludge was found. It is a those places where wind impact seems to be minimal.

Other Ponds not in Use

Areas of these ponds are very similar to the ones in use. The depth of the first and third pond is also very similar, however the second pond shows strong variations in depth. This pond has very shallow sections.

HRT

The calculated HRT for one series of ponds is 25.5 d (Tab. 2.). The effective HRT because of stratification and sludge build up.

BOD Effluent

The effluent BOD from pond one varied between 30 and 187 mg/L (0). The design falls in this range. The BOD of the final effluent varies between 9 to 128 mg/L. The design is 11 mg/L. The BOD/COD ratio is already rather low for the influent to the ponds. This could be due to the analytical method used, the dilution through infiltration water and treatment in the conveyance system. This is either caused by the analytical method or the removal of BOD in the wastewater transportation system.

There are implications for the relevance of BOD measurement in a pond system given the production of algae. Algae is necessary for the removal of nutrients. The fact that algae consumes oxygen in the dark and produces oxygen in the light, influences the BOD measurement. To be able to do so one has to differentiate between the contribution of BOD from algae and the BOD from the sewage (organics). Because of this the COD- mixed and the COD-filtered provide a better indications for the removal of organics.

COD Effluent

The COD in the effluent varies between 95 and 110 mg/L in the effluent (0). The COD of the filtered effluent varied between 33 and 80 mg/L, indicating that suspended matter contributed significantly to the COD in the effluent.

The COD better describes the removal of organics from the wastewater than the BOD.

SS Effluent

The suspended matter in the effluent ranged from 18 to 35 mg/L (0). From the observations the conclusion can be drawn that the algae mainly contribute to this value

Faecal Coliforms

The design figures for Faecal Coliforms exceeds the standard of 1000 MPN/100 mL (0). The actual levels vary between 1100 and far above 2400 MPN/100 mL. This number was not always specified. Once the value was presented as 9200 MPN/100 mL.

Additional Comments on Design

Compost Filter

The compost has been designed to remove the odour from the off gases of the pump sump, however measurements indicate that none and sometimes up to 30 % of the hydrogen sulphide has been removed. The filter is filled with coconut fibres, however no compost ahs been found in between them. The compost filter has no access to the bottom part to investigate the conditions at the intake.

The addition of potassium permanganate, thrown through the top of the filter, actually reduced the odour for a short period of time.

The compost filter does not continually treat the off gas of pump sump # 3. Every time the wastewater pump switches off, the blower switches off for a short period of time as well.

A detailed design of the compost filter was not available on-site. Easy accessibility to floor of the filter as well a to the filter material may be required. The selected filter material is not appropriate. It is recommended to install compost filters at all pump sumps to reduce the complaints of the local people and tourists. However, before doing so, a better understanding of the process (analysing the existing compost filter in detail) and the selection of appropriate compost, as well its longer-term behaviour has to be obtained.

Pump Sump

The pumps sump structures are according to design. However there are some points which require attention:

- Saltwater infiltration into line 3 has been detected. From measurements during a demonstration of on-line monitoring it is known, that also salt water intrudes at the sump of pumping station 1. The flow at pumping station 3 is relatively high during nighttime. While the flow slowly drops, the salt content continually increases

- A minimum of 40 cm WC is left in the sump. This offers best conditions for settling. Not only sand, but also coarse organic material will have a significant longer residence time in the sump. Some thought on how to reduce the residence time of the wastewater in the sumps may be required.

- Different causes for the odour production (hydrogen sulphide) along the sewer line: Storage of waste water before being discharged to the sewer, attached growth in the sewer, pockets in the sewer where the flow velocity is reduced similar as at the siphon, the dead volume in the sumps (long residence time) and the rather flat bottom of the sump. Compost filters, which may also be fed with the air from the sewer line, if operated adequately, are most appropriate to reduce the odour.

- Proper access to pump sumps for sampling, routine maintenance and safety (getting out) is required.

- Follow up of repairs is not clear. Only one pump was available at pump sump 3 since around three weeks. This indicates, that there may be a need to follow up repairs more strictly.

- Cable shaft was full of water. Proper drainage has to be provided.

Venturi Canal/Screen

No design, nor the calibration formula for the Venturi canal, was available.

There are some points for consideration:

- Some monitoring equipment is on-site available, however spares are scarce or not available. In particular with respect to safety, calibration gas should be obtained.

- The flow meter at the Venturi canal is fixed improper. The question whether the level measurement in pump sump 11 cannot better used for flow measurement should be elaborated. This would additionally be able provide more details on the flow variations and the pump capacity at the same time.

- Screws launders are corroding. They need treatment.

- Comparison of the available hardware and questions turned up because of the smell problems will lead to a careful rethinking of the design or implementation of minor modifications to tackle the problems. A system needs to be in place so that the inconveniences, the matters learnt and the new solutions are presented. Preferably this there should be “check lists” of the alternatives considered together with advantages and disadvantages of every solution thought through.

- Are the access to inflow and outflow structures, not to speak about those to the pump sumps, easing work?

- Is there a need for a venturi canal at the ponds at all?

- Is a screen after the venturi canal the proper location?

- Is the screen required at all?

Comments on Structures

Generally there was consideration in the construction of the structures for access for repairs and maintenance. For example it is very difficult to access the pump sump at pumping station 3. Additionally safety was not fully considered, as there is no staircase in the same staircase to ascend from the area.

In terms of structures and fittings, concrete was seen flaking from the surface at different places, fittings were corroding and loose, and covers not fitting properly in the seats.
There appear to be a number of superfluous structures.

A cable shaft was observed to be full of water and this suggests a check to be done to correct this problem, wherever they occur throughout the system.

Infiltration water was detected at pump sump 3 and this suggests that the sewer lines are not sealed properly. This can be due to setting of the sewer pipes or improper laterals or both.

Comments on Operations of the Pond

The ponds are a complete flow through system. There are other than, lifting the weir at the outlet, or/and distributing the waste water to two series of ponds, no facilities that aid in the control of the treatment process, for example sedimentation.

General Observations

In addition to reviewing design criteria, the consultants also made a number of general observations which may impact on treatment performance.

- Short-circuiting was observed to be caused by a number of factors: Wind direction, water temperature, salt concentration and surface tension. In the case of the wind direction a change from Northwest/Northeast to South resulted in the influent going almost directly into the effluent of pond 1. Baffles could help to minimize this problem when such a change occurs. Temperature gradients result in stratification, thereby reducing the effectiveness of treatment. Ammonia levels were significantly higher during periods of short-circuiting.

- The applied design formula for the removal of Coliforms from ponds suggests that better removal is achieved when all ponds are operated in series.

- The influent pipes into the ponds is below the level of the water. This appears to have been done to minimize odour release. However, this prevents observations.

- There is no provision for the removal of surplus sludge. Given that the ground water table is fairly high, there will be a need from time to time to dredge the ponds. In pond 2 and 3 sludge build up created anaerobic conditions which leads to the break down of algae and re-solubilisation of nutrients.

- Grease adds to the organic loading and in Negril, the scum layer which partly consists of this, was broken and mixed into the water rather than being physically removed.

- Storm water appears to enter both ponds 1 and 4.

- Particularly in the mornings the fish are swimming near the surface in pond 3 and birds are feeding from this ponds suggesting an oxygen deficiency a oxygen deficiency in the maturation ponds.

- The marl, used for the construction of the dikes, has disappeared near the water surface, indicating that it has been dissolved in the water. Dissolution of marl occurs quite rapidly, in particular at lower pH values. This observation suggests that another material may need to be considered for making structural improvements to the dikes.

Options for Improvements

The design criteria for the ponds effectively deals with organics removal and Coliforms removal. The Negril waste water treatment facility, even though it is currently operating at around 30 % of the design flow rate, is not consistently meeting design criteria nor NRCA effluent standards. The assessment found some limitations in the design criteria, particularly as it relates to nutrient removal. Given the NRCA standards and the environmental concerns (locally and globally) this limitation should and can be corrected.

This requires a consideration of the following options:

Option 1: Pre-treatment

- Anaerobic, with or without simultaneous precipitation of Pre-treatment.

Anaerobic treatment

Anaerobic pre-treatment is recommended to reduce the organic load to the ponds, thereby creating more area for facultative and maturation ponds. Anaerobic treatment would produce low amounts of sludge, can be operated at short residence times (low space demand), at a favourable temperature during probably all year around and collects the gas (no released straight to the atmosphere) for use as an energy source (electricity generation) a fine screen is probably required to secure good distribution of the waste water in the anaerobic reactor.

Simultaneous P-Removal

Simultaneous phosphorous removal during anaerobic treatment should be taken into consideration.

Option 2: Improve Existing Ponds

- Anaerobic/Facultative with recirculation and start using all ponds possibly with precipitation

Operate Ponds in one Series or Introduce separators (Increase Flexibility in Operation)

According to the design formula for Coliformes decay, a series of ponds would result in better removal rates. It is recommended to find an indication whether this is true so that a decisions can be made whether changing the flow regime would be an option.

Also the introduction of separators (like MoBay) could improve pond performance for settling as long as the impacts of the wind is minimised. The settled sludge will degrade anaerobically as now in some corner of pond 2 and 3 thereby releasing nutrient to the surface water. The nutrient cycle will not stop.

Simultaneous P-Removal

Simultaneous phosphorous removal during pond treatment should be taken into consideration.

Scum and Sludge Removal

Scum on the surface and settled sludge are natural phenomena. In many occasions, the scum could be left where it is, while carefully observing treatment performance, in case the scum deteriorates treatment performance one way is to destroy the scum layer and the other is to remove the scum layer and find out whether drying on drying beds is a solution before the disposing of the matter. Equipment is required to remove the sludge from the bottom to maintain effective volume of the ponds.

Returning Effluent to Pond 1 and/or Pond 2

While the oxygen concentration is high, returning effluent to pond one may improve its performance while at the same time algae may settle out. However there may be a danger of smell problems which cannot be predicted (see MoBay ponds). Nevertheless it is seen as worth while to test this option.

Controlled Distribution of Flow

Controlled distribution of flow could be useful to investigate the sizing of the treatment plant at full load/flow. The is, however, not found a distribution in the inflow canal to the pond which allows this. A long as it is not decided to operate all ponds n series, such feature could assist in obtaining useful data for the empirical design of ponds.

Option 3: Post Treatment

- Precipitation of Phosphorous
- Irrigation

Pond Effluent for Irrigation of Swamps

Pond effluent could be used for irrigation of the swamp area with a falling water level. The nutrient load which can be applied requires determination. Nutrient will enhance vegetation growth, overloading with nutrients could have negative impacts, thus the good distribution of water to the area may be required. Since the impacts cannot be predicted, it is recommend to select a piece of swamp and irrigate thus while monitoring the changes carefully for potential full scale design.

Filtration

High rate filtration or low rate filtration over for example red mud solids could be an option for nutrient removal.

Fig. 5 illustrates the treatment options. In addition there are some general improvements which can be made and these are also detailed in the following section.

General

Pump Sumps

Modify pump sumps so that the dead volume, the volume for sedimentation is minimized. After ensuring simple access to the sumps, investigate the actual settling of solids to decide how they can be avoided and how to the residual volume of the sump can be or is reduced.

Due to the fact that the waterfalls into the sump, a test could be carried out where the water only runs into the sump below water level, basically the same principle that is applied at the ponds, but not at other places. The water volume in the sump would increase, however one could expect the air release to be less.

Flow Measurement

Use level measurement in Sump 11, basically every sump, for flow measurement. Proper calibration is required. In order to do so, equipment is required to close the incoming sewer for short periods, so that the empty sump can be emptied for taking exact measurement to determine the volume at different levels.

The flow measurement at the ponds in the Venturi canal will become superfluous, when there is no additional sewage entering between pump sump #11 and the inlet to the ponds. The outflow of the ponds is required to determine the load of the receiving water. Therefore a flow measurement and volume proportional sampling would appropriate at this point.

Phosphorous Precipitation by Red Mud and other local available materials

Since the only effective reduction of the load to the receiving water is to use the N and P in the swamp or to precipitate the P together with the algae that have removed the nitrogen, it is recommended to test different local materials to precipitate or to flotate algae.
There are different flocculation aids on the market which should be tested, preferably in such a way that a methodology is found to use the algae as a potential protein source. Trying to grow the algae as strings could be another solution, however o experience exists and algae recovery is still a technological challenge.

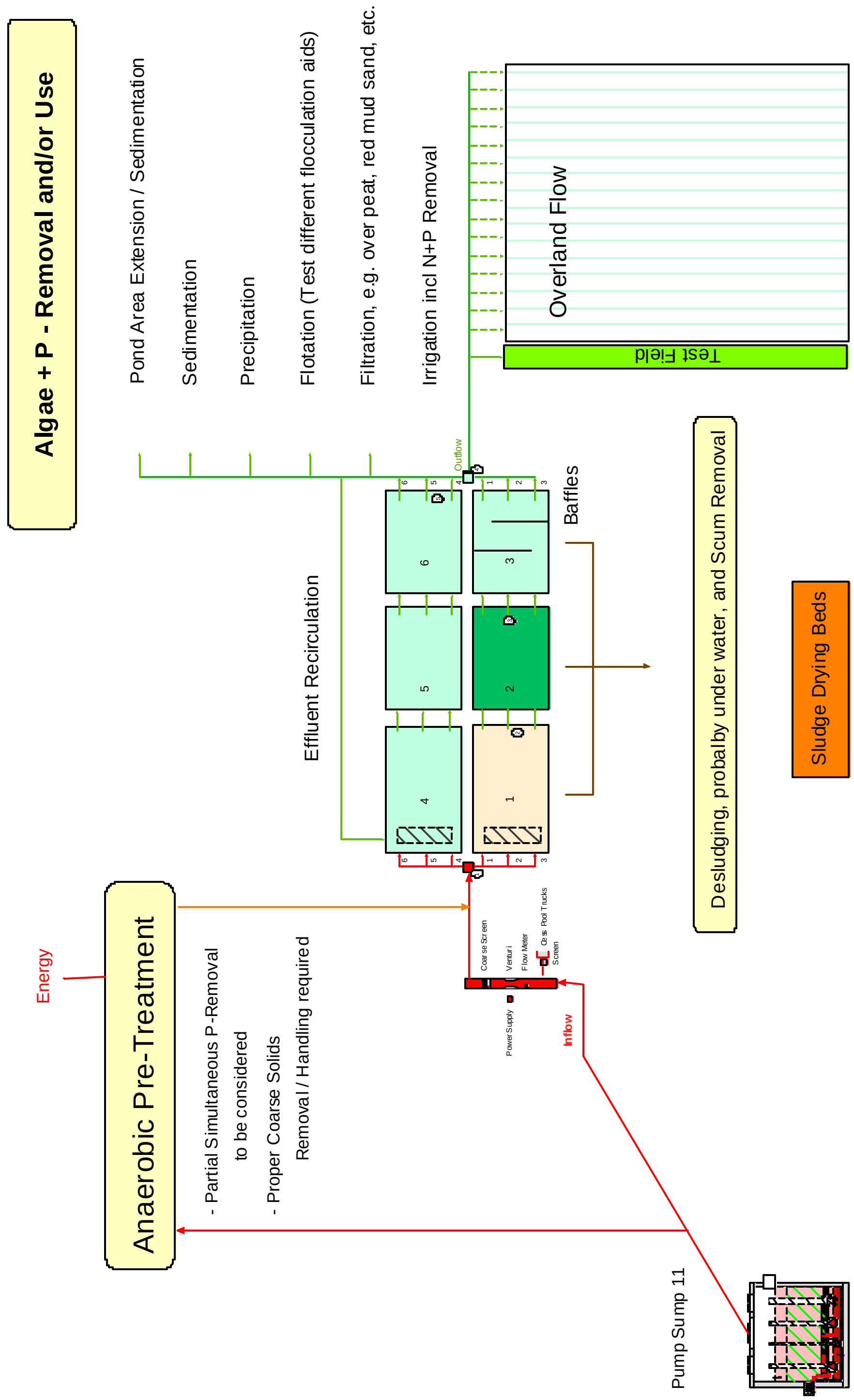


Fig. 5 **Pond Treatment Options for Upgrading / Extension**

Pond Design

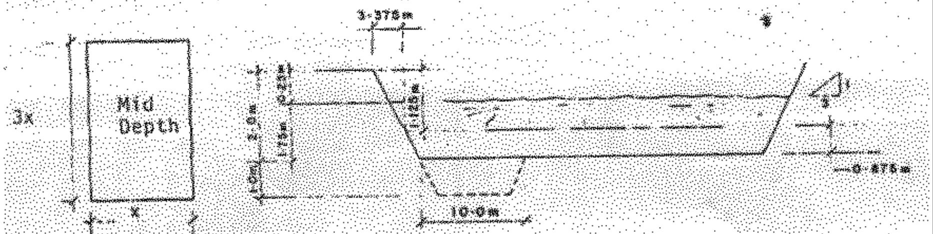
POND FLOWS AND DESIGN

1. 2015 Flow Analysis
2. Sewage Pond Design, J.P. Arthur's Paper
3. Sewage Pond Check Design
4. Sewage Pond Dimensions

SHEFFIELD POND: LEED'S UNIVERSITY PROGRAMME RESULTS

Facultative Ponds

1 No; mid depth area (m.d.a.) = 63,953m²
if 2 No; = 31,977m²
say 32,000m²



MID DEPTH PLAN

SECTION

3X x X = 32,000 x = 103.28 m
3.375
3.375
110.020m

say 100m

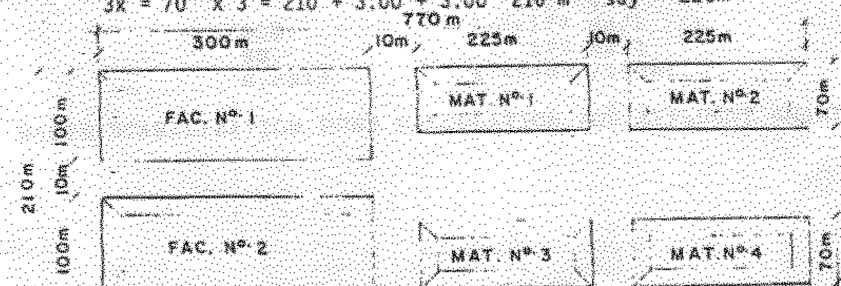
3x = 100 x 3 = 300 + 3.375 + 3.375 = 306.75 say 300m

Maturation Ponds

2 No. ponds each of mid depth area = 26,496m²
if 2 No. parallel streams, each pond mda = 13,248m²
say 13,000m²

3X x X = 13,000 m² x = 65.83 m
3.00
3.00
71.83 m say 70m

3x = 70 x 3 = 210 + 3.00 + 3.00 216 m say 225m



TOTAL AREA = 210m x 770m = 161,700m² = 16.17 ha

NEGRIL SEWAGE WORK'S FLOW ANALYSIS
2015 PEAK TOURIST SEASON JdeBA, 26/7/91

WASTEWATER AVERAGE UNIT FLOWS
NEGRIL TOWNSHIP
Reference the Spread Sheet Population & Flow Analysis.

		m3/s		
Av Flow:	Cliff Rd Sewer:	0.0552		
	Ribbon Garden:	0.1010		
	Garden Rd:	0.0300		
	[illegible]	0.0410		
	[illegible]	0.0046		
	[illegible]	0.0176		
	[illegible]	0.0144		
	[illegible]	0.0017		
	Reverse Gr Rd:	0.0257	TOTAL:	0.2917 m3/s

Ultimate Population: 69860
Average Waste Flow: 361 l/cap day

. BLOODY/LONG BAY TOURIST
Reference the Spread Sheet Population & Flow Analysis.

		m3/s		
Av Flow:	Long Bay 6:	0.1006	TOTAL:	0.1006 m3/s

Ultimate Population: 15167
Average Waste Flow: 573 l/cap day

. DATA

Consent, 50%tile BOD:SS:E.coli, mg/l:mg/l:/100ml:	25:30:2000
Average BOD:SS:E.coli, " " "	25:30:2000
Design Pop Resident (PR), 2015:	19900
Design Pop Tourist (PT), 2015:	15167
Total Population, 2015:	35067
Average Wastewater Flow, Resident (WR), 2015:	361 l/cap day
Average Wastewater Flow, Tourist (WT), 2015:	573 l/cap day
BOD Loading:	80 g/cap day
SS Loading:	80 g/cap day
Raw Sewage Escherichia coliform:	2.4E+07 /100ml

2. FLOWS

Wastewater Flow, (PR*WR)+(PT*WT):	0.184 m3/s
Design Flow to Treatment:	0.184 m3/s

3. CRUDE SEWAGE: AVERAGE DRY WEATHER FLOW (DWF)

	Influent
BOD:	177 mg/l
SS:	177 mg/l
E.coli	2.4E+07 /100ml

SEE WASTE STABILIZATION POND CALCULATION FOR EFFLUENT ANALYSIS

WASTE STABILIZATION POND CALCULATIONS

NEGRIL PONDS, PEAK TOURIST FLOW, 2015 JdeBA 26/7/91

REF. J P ARTHUR'S WORLD BANK PAPER NO.7

1) DATA

WASTEWATER INFLOW TO PONDS: Q= 0.184 cum/s

15898 cum/d

INFLUENT STRENGTH, BOD [illegible] Li= [illegible] mg/l

BOD LOADING [illegible] L= [illegible] kg/d

[illegible] /100ml

[illegible] T= [illegible]

[illegible]

/100ml

2) FACULTATIVE PONDS

A) SURFACE LOADING 20T-60 SLf= 440 kgBOD/had

Take BOD removal of anaeobic pond as 60%

B) INFLUENT STRENGTH =Lif Lif= 177 mg/l BOD

C) MID DEPTH AREA =10*Lif*FLOW/SLf Af= 63952 sq m

Take pond depth as 1.75m

D) POND VOLUME =MID DEP AREA *1.75 PVf= 111915 cu m

Take effluent removal as 70%

E) EFFLUENT QUALITY = INFLUENT*30% Lim= 53 mg/l

F) RETENTION TIME = VOLUME/ FLOW tfac= 7.0 d

3) MATURATION PONDS

Take 2No ponds in series,at 2.50 days eachtm= 2.5 d

A) EACH POND VOL= 2.50 day*Flow PVm= 39744 cu m

Take pond depth as 1.5m

B) MID DEPTH AREA = POND VOL /1.5 Am= 26496 sq m

4) EFFLUENT QUALITY (prior to tertiary treatment)

A) Faecal coliform (E.coli) removal is based on first order kinetics

Kb(T)=2.6(1.19)^(T-20) Kb(T)= 6.20

Final E.coli for the ponds in series is :

Be = E.coli /(1+Kb(T)*tan) * (1+Kb(T)*tfac)* remainder of ponds

Be= 1970 E.c/100ml

B) BOD QUALITY

Overall BOD removal of the raw sewage: 94 %

Le= 11 mg/l BOD

DESIGN DATA

Summer temperature = 25 [deg.C]
Winter temperature = 25 [deg.C]

Wastewater flow in summer = 10000 [cu.m/day]
Wastewater flow in winter = 15898 [cu.m/day]

Wastewater BOD5 in summer = 177 [mg/litre]
wastewater BOD5 in winter = 177 [mg/litre]

No of faecal coliforms = 2.4E+07 per 100ml in summer
No of faecal coliforms = 2.4E+07 per 100ml in winter

Required effluent standards for faecal coliforms:
2000 per 100ml in summer
2000 per 100ml in winter

[illegible]

[illegible]
[illegible]
Maturation pond: 1.5 [metres]

Minimum retention time in maturation ponds = 2.5 [days]

DESIGN CALCULATIONS

Design is controlled by winter conditions

Pond series comprises:

1 Primary facultative pond and
2 Maturation ponds

NOTE: Areas given below are mid-depth areas

An anaerobic pond was found to be infeasible due to a retention time <1.0

Details of facultative pond:

Primary facultative pond

Area = 63953 [sq.m] = 6.3 [hectares]
Retention times: 11.19 days in summer and 7.03 days in winter
BOD5 loadings: 276 [kg/ha.day] in summer and 440 [kg/ha.day] in winter

Details of maturation ponds
Only one design option

Number of ponds = 2
Area of each pond = 26496 [sq.m] = 2.6 [hectares]
Retention times in each pond: 3.97 days in summer and 2.5 days in winter

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Final effluent quality:
In summer 517 faecal coliforms per 100ml.
In winter 1970 faecal coliforms per 100ml.

Overall area =  52993 [sq.m] = 5.2 [hectares]
Overall retention time:  7.94 days in summer and 5 days in winter

* * * * * *

                    * * * END OF DESIGN * * *
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Getting Started

Working within the Scope of the Coastal Water Quality Improvement Project

At NWC – Preparing to Meet the VP of Operations & COO, Mr. D. Malcolm

Meeting with Mr. Dean Williams Operations Manager – NWC Negril

Suspended Solid Meter at NWC Negril Office

2. “Around Pump Sump 3”

Signage at Number 3 Pump Station

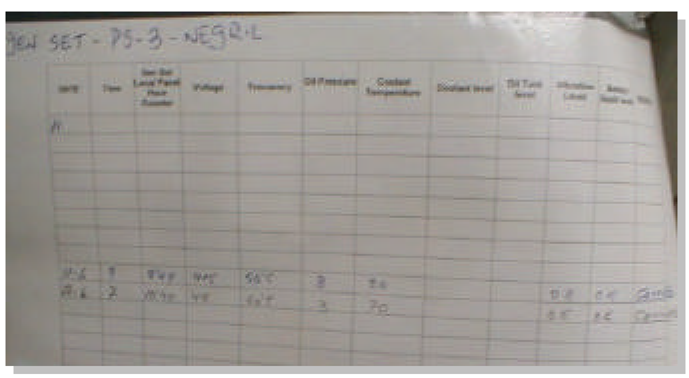
Corroded Covers at Number 3 Pump Station

Safety Equipment is Already Available on Site (requires practice and training)

Safety Equipment Demonstrated

Hydrogen Sulphide – Meter being lowered with Sump

A Tyre in the Influent Distribution Canal in the Sump of Pumping Station Number 3



Emergency Power Supply

Monitoring Protocol Attached to Generator

Reading H2S levels the Sump at Pump Number 3

Manhole Location – Last One Before Pump Sump Number 3

Analysing the Hydrogen-Sulphide Concentration which is Significantly Higher than in Sump 3

Manhole to which the Water from the Sump is Discharged

Start of Sewer Line 4

Hydrogen-Sulphide Concentrations are here far lower than in the Sump and in the Incoming Sewer to Pump Sump 3

It did smell very unpleasant at this place between pumping station 3 and 4

Occasionally it smelt bad from the Pump Sump too during on-line monitoring and sampling

Sample Hose and Power Line (yellow Sulphur?)

Visitors Observe the Data on the Screen

Sample Storage

Shipping before Ice is Added

3. Intake to the Compost Filter

Blower to feed the Compost Filter

Condensate Pipe form the Compost Filter
With Intake Pipe to the Compost Filter

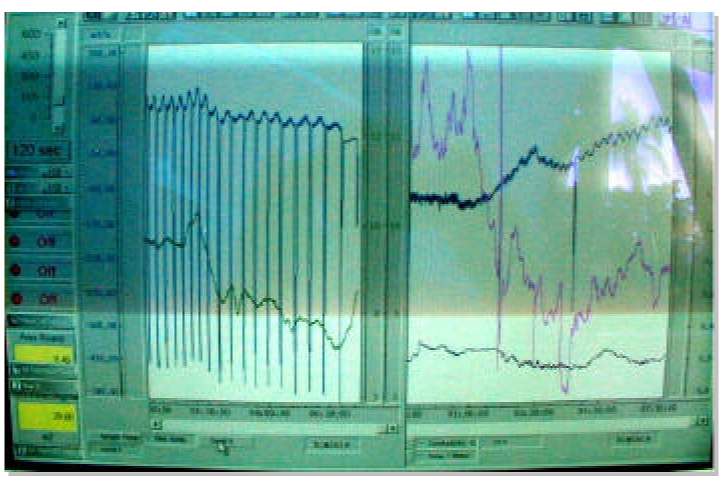
Discharges to the Sump in Emergency Cases

Quality of the Surface Layer is Unsatisfactory

4. Pump Sump 3 Guests

More Visitors

Explaining the Present Situation at the Screen

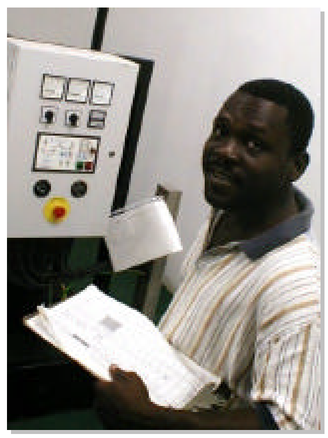


Conductivity is Increasing during the Night

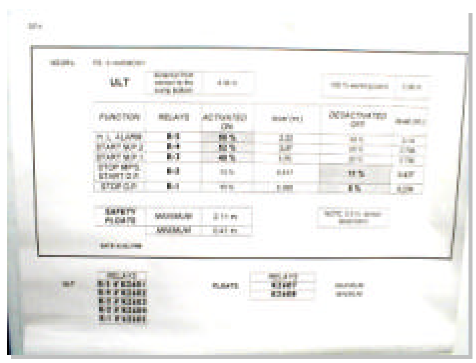
Show Settleable Solids to Visitors

Typical Settleable Solids in the Waste Water from Pumps Sump 3
Whitish at the Bottom and Dark Grey Above

Heavier Flow into Pump Sump 3



Operator Checking the Generator



Control Panel with Level Measurement in the Sump
Important Data Readily Available

General Alarm on for Around 3 Weeks

5. In the Sump at Pump Station 3

One Big Pump is not Working since 3 Weeks

Not Easy to Work in the Sump
No Staircase as in the Manholes, No Walk way for Cleaning

Cable Shaft Flooded. Is this the Reason for the Failure of the big Pump?

Check Electricity Supply to Monitoring and Control Unit
(Proper 220 V in contrast to the 220 V at the ponds)

Inflow to Compost Filter 15 and outflow 11 ppm Hydrogen-Sulphide
No easy Access to Inlet of Air and Bottom Distribution
Condensate?

Cross-checking Current
(For Adjusting/Checking the Ampere meter Displays)

Coconut fibres, an excellent filling material

However, there is no compost to be seen in the Compost Filter

Spare fibres are available

6. Pumping Stations 1 and 2

Pumping Station Number 1

Pumping Station Number 2

Pumping Station Number 2

7. Pumping Stations 3 and 4

Pumping Station Number 3

Overflow at Pumping Station Number 3

Pumping Station Number 4

8. Pumping Stations 5 and 6

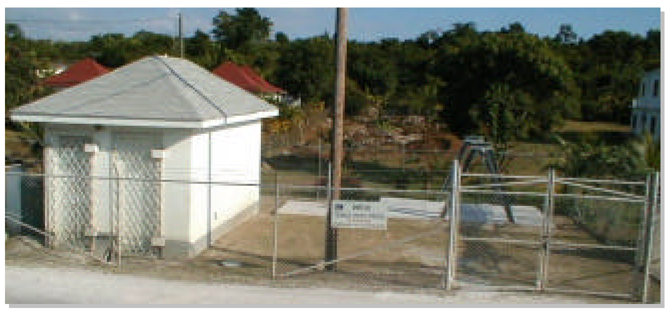
Pumping Station 5

Pumping Station Number 5

Pumping Station Number 6

9. Pumping Stations 7 and 8

Pumping Station Number 7



Pumping Station Number 8

10. Pumping Stations 9 and 10

Pumping Station Number 9

Soil and Plants at Pumping Station Number 10

11. Pumping Stations 11

Pumping Station Number 11

Pumping Station Number 11

Pumping Station Number 11

12. Treatment Ponds: Two Times 3 in Series

Left: Non Fed Ponds, Right Ponds Fed with Waste Water
Left: Clear Impact (Turbulance) caused by Wind, but right no impact to be seen

Protection of Power Supply Cable and Level Sensor Cable

View on the Ponds from just Above the Venturi

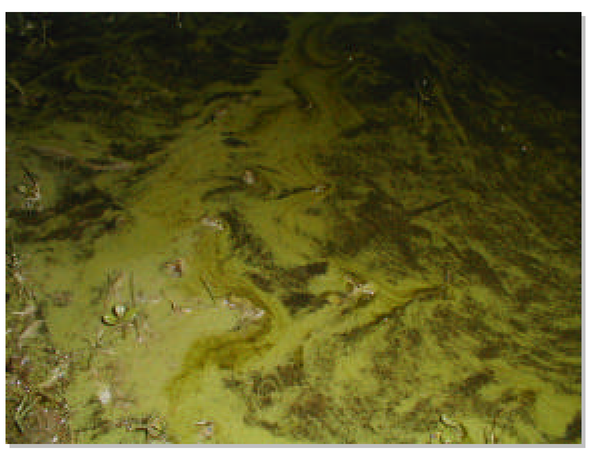
Sufficient Slope
Cows Around

Cows May not Read

Grass Grows in Shallow Water
Near the Dike of Pond 4

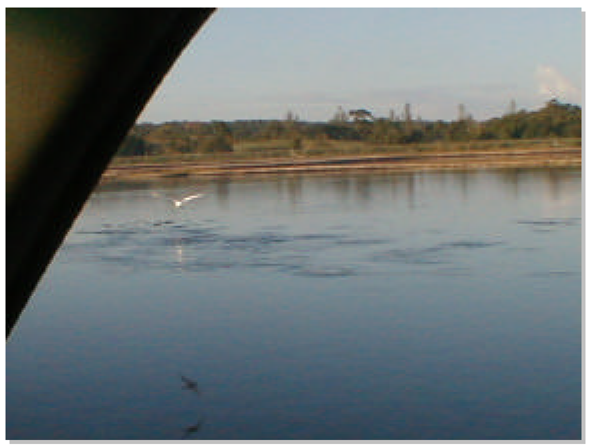
Algae Early Morning

In Close Up



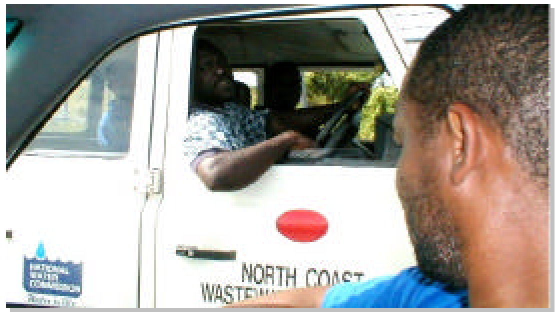
Algae at Night in Pond 6

Birds Waiting for Fish in Morning



Sufficient Fish, Early Morning near the Surface, Indicating a Lack of Oxygen
(Anaerobic Conditions in Close to the Surface (Facultative Pond)

Effluent Pond 1, 2, 3, and 6

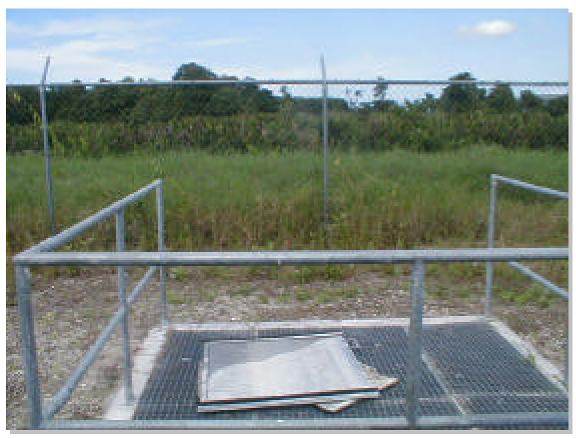


Exchange of Information

Watching the Data, Waiting for the Daylight to Come

Settling takes place or took place. This crack did not change over the past 2 years

Marl Washed Away under the Lining



Launder around an Outlet which is Protected by Screens

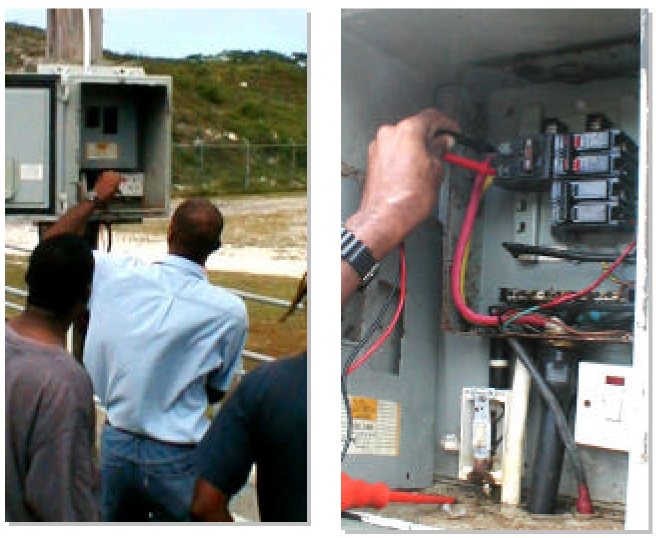
No Easy Access
(No Open Canals and No Places to Check flow Easily)

Screens are Partly Tight and full a Sand

Pontoons are Stranded
Made of No Suitable Material and Too Heavy to Move Easily from Pond to Pond

Observations and Waiting for Electricity

Corrosion at the Venturi Canal
Pipe not well Treated
Screws proper, but at another Place improper screws



Power switch to electricity control outlet

13. Pond Inflow and Outflow

The three inflow pipe to pond 2 Pipe Flows into heavier Floating matter

Outflow Structure of Pond 2, Pond 1 has no visible effluent pipe

The Surface is very inhomogeous, thus it is difficult to sample

Sampling

14. Sampling At Treatment Ponds

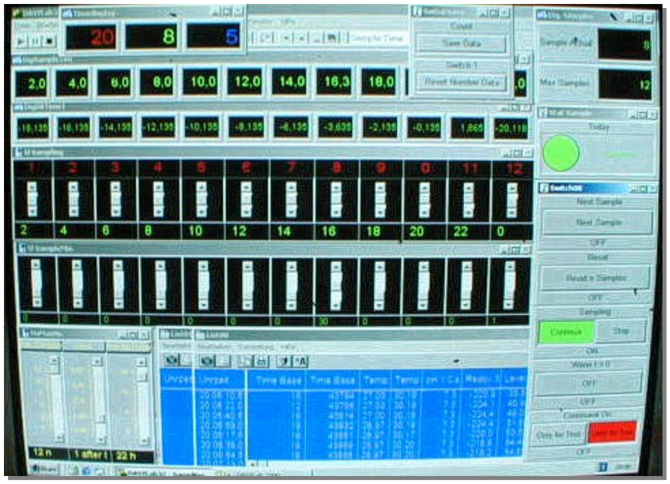
Sampling Point for Effluent of Pond 3

Algae produce Oxygen in the Effluent of Pond 3

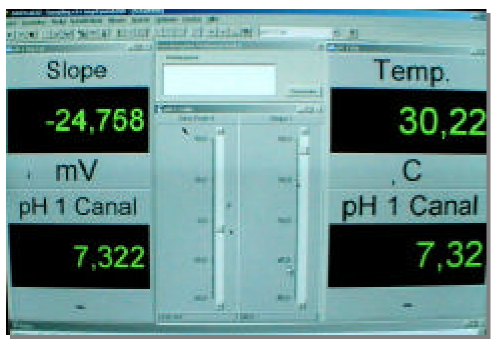
Samples of One Day
(Green, Red and Grey)

An Exceptional Influent Sample (Reddish)

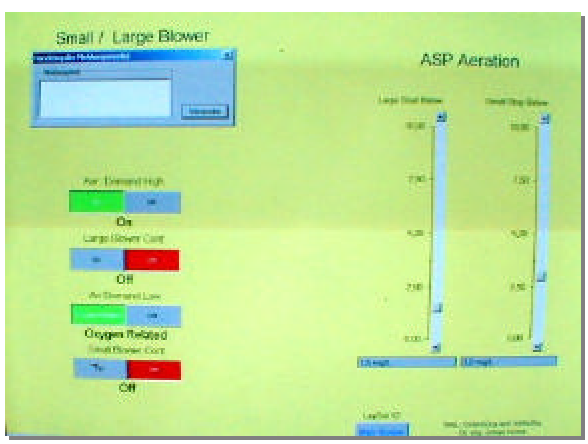
15. Monitoring



Screen for Sampling Schedule and Time Setting

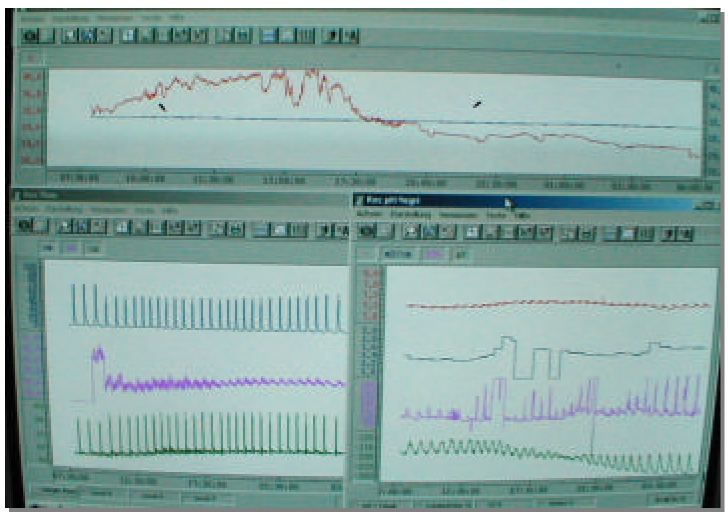


Screen for PH Calibration



Screen for automated Aeration of Activated Sludge Pilot Plant

Reading Conductivity and Oxygen

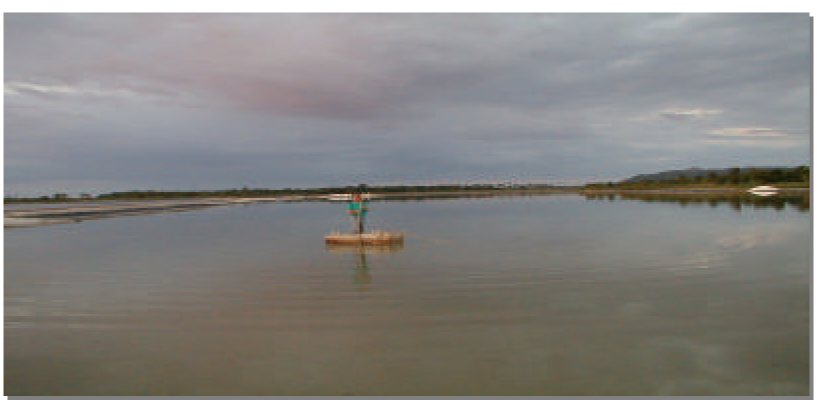


Computer Screen

16. Depth Measurement of the Ponds

Entering Pond

Lining up Boat



Tallying Measurements

17. Venturi Canal

Venturi Canal and Cess-Pool Emptier Unit (Not in Use)

Significant Quantity of Water Stands that Unit

Entrance into the Venturi Canal

Inflow to Venturi Canal

Is the Flow in the Venturi Canal Proper?

Level Sensor is not Functioning Anymore

Wind Has Free Play with the Sensor

No Shooting Flow in the Venturi Canal, No proper Flow Measurement Possible

No Wondering, the Screen Requires Cleaning

18. Pilot Plants in Operation

Activated Sludge Plant and Upflow Anaerobic Sludge Blanket Reactor (ASP and UASB)

Inoculum for the UASB and ASP

Scum formed on the ASP which was filled with Scum from Pond 1

Smells good after 6 hours of Aeration, but still Foaming

Explanations to Visitors

Filling Anaerobic Sludge into the UASB Reactor

Gas production Starts Immediately when Feeding Sewage at an HRT of 6 h.

A significant Amount of Gas Produced, however the Feeding Rate was too High

CWIP

Coastal Water Quality Improvement Project